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The SciVerse: a Metaverse for Scientists, Engineers and Scientific Outreach

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Exec Summary *If anything has been proven during the time of COVID19 is that we can work remotely and effectively, however the number of tools available to scientists, engineers and communications leads is few. Enter into this two new factors: 1) inexpensive Virtual Reality (VR) headsets; 2) the coming of age of the Metaverse. Suddenly there are a plethora of communications options to choose from, with everyone seeking to provide a viable solution to an enormous market of consumers. Scientific, engineering and comms needs differ markedly from those of the consumer market, and we outline here how we can build upon SciVista's offerings of SummitVR™ to generate the SciVerse: a secure universe in which to share, communicate and present data, CAD and other scientific insights.*

A lot has been written recently about Mark Zuckerberg's rebranding of Facebook to Meta, and his announcement that he will be spending $10Bn per year[1] to build the **Metaverse**[2], a 3D digital world that can be accessed through VR headsets. While this might be exciting for the consumer market - allowing people to connect and interact with others in new and interesting ways, building their own digital worlds - the scientific community demands greater data security. There is therefore both a problem and opportunity, both are further explored here.

A Metaverse is now possible because Virtual Reality has now come of age: it is possible to use this human-computer interface productively; and, in many instances, VR provides a better experience than using a flat screen. VR is now adopted by the DOD for training pilots, in medicine for training doctors and practicing surgical techniques, and in education, science, retail, and many other verticals, there is adoption of this technology. There is now also a trend to make 'digital twins' of production lines, components, technology, and practically anything, to examine with AI and ML tools workflow optimization, material property optimization, that can all be ported into VR. The transition to this data intensive world is supported by muscular Simulation and Data Management (SDM) systems, able to handle the integration of massive datasets from disparate sources.

At SciVista, Inc., we have developed a collaborative VR data visualization platform, called SummitVR™. We had support from the US Department of Energy in the SBIR program to do this. This platform ingests almost any data type because we have integrated Kitware's Paraview, a leading data visualization tool. We can also read practically any CAD data type, which means that we can put scientists, engineers and the general public into devices such as NIF, OMEGA, ITER, W7X, MAST-U, STEP and other systems to scale, and rendered in a way

[1] https://www.theguardian.com/technology/2021/oct/28/facebook-mark-zuckerberg-meta-metaverse
[2] The name 'Metaverse' has been appropriated from Neal Stephenson and his novel Snow Crash

that appears real. Into this contextual environment we can bring time-dependent datasets, which allow scientists to present their findings in an immersive, engaging and impactful way, communicating with colleagues in remote locations as if they were present.

However, this is the beginning of the story. We are building SummitVR using Unity - a game development platform, which is a high level language with many 1000's of assets that can be brought into the code easily, making the development process straightforward with a very short learning time. We have built the platform to operate anywhere: we have a cloud version, which allows the user to log on to an AWS instance, but we have also built a super-secure, on-premises-only (no communication across the fence) version for customers at National Labs. We are ready to deploy this solution with three labs to test communications across secure networks.

Figure 1. Staff at United Kingdom Atomic Energy Authority experience the SciVerse through SummitVR, seeing into CAD models of fusion energy devices and connecting with those in the USA.

This is where things start to get interesting, because, in essence, **we are building a secure metaverse for science: the SciVerse**. With adoption of the platform by the national labs, we can connect scientists and they can communicate, collaborate and share CAD and data in the most secure data environments on the planet. This **SciVerse** will allow scientists rest assured that there will be no data leaks, no possibility for data to be used by a corporation for profit, and no possibility that they will have advertisements blasted at them. The underlying code is accessible to all, so can be adapted by the end user for particular applications for which perhaps a Q clearance is necessary. The scientists and engineers have control over the SciVerse. Building on this platform at the labs, there will similarly be an explosion of adoption and creative expression for visualizing and communicating results. There will be many new ways to meet and work together. It will be possible to present design reviews with engineers bringing their CAD to see and understand interferences in real time. …

The **SciVerse** starts with the ICF/IFE program, but will end with interoperability with other metaverses. We start with the hardest problem: enormous datasets that can only be shared on closed (Red) networks, simulating some of the hardest physics problems known. To connect the Red network to other networks, the dataset will need to be reviewed and released to the Purple and Yellow, which can be built into the platform: R&R of data can be expedited by building the approval process into the platform. That way, the SciVerse can operate across security levels, out to the outside world for outreach and communication to wider audiences. Universities and other laboratories will be able to connect to the Yellow network, but use of non-secure networks will require that the security is built into the platform for data in transit. The highest levels of encryption will be used.

Security even drives the technology selections within each security zone. Within the Red network 'on-prem' solutions but results in a tethered experience (headset and controllers hard wired to the computer with no RF communications). In due course low latency, high-security requirements and non-tethered AR/VR/XR solutions will leverage the low latency afforded by new 5G networks and in conjunction with the radio interface a secure 5G 'slice' can be created via the new 5G core 3GPP standards.

The future of mobile (non-tethered), secure, photorealistic and real-time AR/VR/XR experiences is reliant upon a low latency network. The time between the movement of the headset and the update of the frame (the motion to photon period) must be around 10-15ms to ensure a fully immersive experience. This fact, combined with the need to 'slim' down headset design and reduce weight, bulkines and increase battery life means that highly compute intensive tasks (i.e. rendering) are shifted to edge compute nodes not further than ~200 miles (C being the limiting factor) away from the end user. This in turn means that utilizing the internet is not feasible due to the lack of peering points and resultant high-latency round trip times.

Alternatively prediction models similar to those used by existing Content Distribution Network (CDN) providers to ensure efficient delivery of data (i.e. the most popular cat video) will be used to ensure data relevant to the end user is made available at the closest edge compute node prior to the required consumption. The complexities introduced by the low latency requirements of VR/AR/XR require an end to end network architecture overhaul. Interestingly the properties of the scientific Red networks support some of the requirements and could be leveraged as a proving ground for the future network architecture developments. In addition to the end to end network architecture required to support the low latency and high-throughput needs there are considerations to be made to the digital content consumed via VR/AR/XR that form the metaverse (i.e CAD, Data Simulations etc). There is a growing need, especially for AR/XR use cases, to maintain the metaverse in such a way that it is in sync with the real universe. Life Cycle Management of digital twins and the associated digital rights (in terms of copyright) require deep integration into real-world events. For instance, a physical change to a device needs to be reflected in the digital twin and the process by which that update is captured, approved and deployed requires robust process policy and adherence.

For Inertial Fusion Energy, we are currently building environments but will be switching to integration of software tools. The environments of interest to us are OMEGA, NIF, built using CAD models of the facilities, but also importing point clouds from Lidar scans of real rooms and buildings, for example the diagnostic rooms at NIF. This read-in of real world environments provides the collaborative space in which meaningful planning discussions can occur - like which port will have which diagnostic. Notes can be taken in the VR space, video and photos records made to export. However, where the platform really comes into its own is by providing much-loved legacy tools a new wrapper, or human interface. We will be building VisRad into SummitVR, by writing the API that communicates with VisRad. The possibilities are quite endless for the tools that can be brought in - as long as an API can be written, we can integrate all tools commonly used in the scientists' or engineers' workflow, and optimize the specific workflow for efficiency by examining the processes typically undertaken in these tools and making them easier and faster in VR. Experimental results are readily ported into the platform, and it is envisaged that V&V can be performed by plugging in the most useful metrics. This development will actually provide the possibility of doing 'integrated simulation and modeling' - providing the possibility of not only connecting simulation tools to VR, but also with each other.

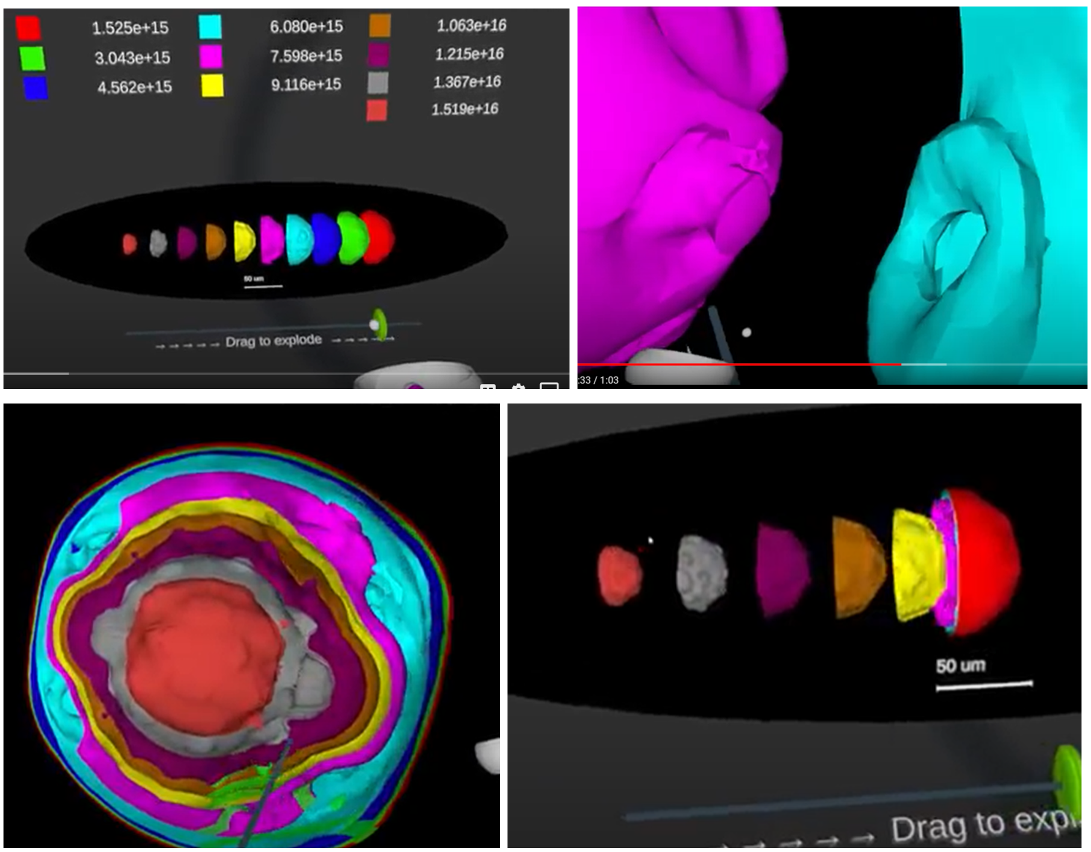

Figure 2. Target implosion data showing iso surfaces of pressure, which can be exploded to reveal individual surfaces, and those can then be explored. [Video here.]

Working with Intel, we have access to some of the most advanced ray tracing tools, which we can build into the platform. Scaling studies by SciVista indicate that 14 nodes of Cascade Lake architecture will provide the frame rate for photorealistic rendering in VR, giving the option of the most advanced visualization experiences to the labs.

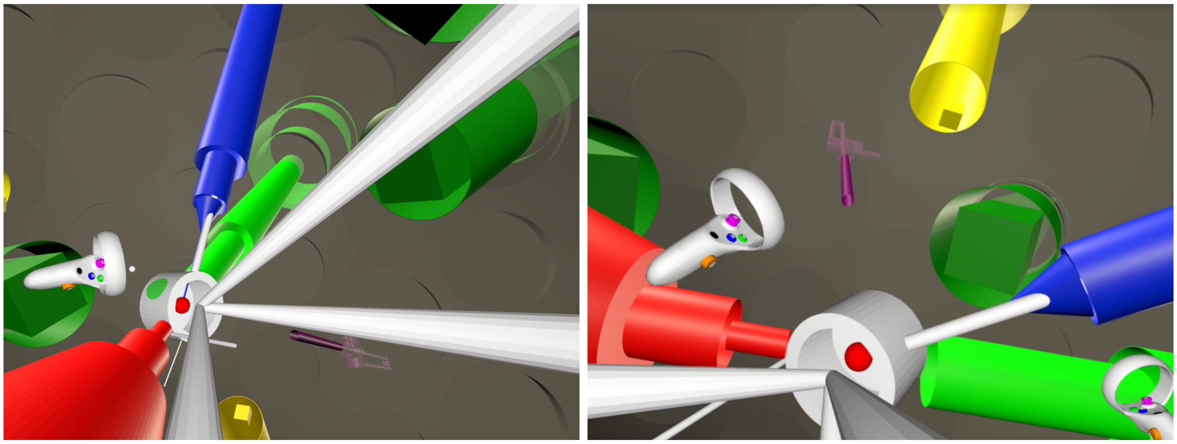

Figure 3. Immersion in a target chamber - showing beam lines (cones exported from VisRad) and diagnostics (red, blue, yellow and green re-entrant components).

Interoperability is key. Outside of the labs, the **SciVerse** can be offered as a commercial solution to large enterprises who wish to expand their communication offerings in a super secure way. There will be interoperability between some versions of the SciVerse and other verses - Nvidia are developing their own version, called the Omniverse for example, but there are many more coming on the market. Interoperability is achieved by use of common file formats: Pixar's Universal Scene Description (USD) file format is used by Nvidia and supported by Unity.

They say that history repeats itself: for us this would be a good thing - the internet started after all, with the national labs in the USA[3], and supported by DARPA, it was called the ARPANET. The opportunity here is to define the **SciVerse** to benefit the national labs, scientists and engineers.

In summary, SciVista can deliver the SciVerse by working closely with those at the national labs and working to provide the features, functionality and security demanded there. We can build this with the scientists, engineers and outreach leaders who will ultimately use it. It will be available to all within the scientific community, much in the same way that the internet became available to all.

[3] https://www.internetsociety.org/internet/history-internet/brief-history-internet/